convex, arranged in a broad triangle. Antennæ short and stout, the funiculus extending barely to occipital border; pedicel slightly longer than thick; funicular joints subequal, cylindrical, one and one-third times as long as broad; apical joint conical, one and one-half times the length of penultimate. Thorax trilobed, lobes convex. Scutellum rounded behind, with a strong transverse impression before the posterior border. Metanotum abruptly sloping, with strong lateral sulci. Petiole from side more than twice as long as thick.

Head shining, finely densely punctuate, the temples finely shagreened; flagellum coarsely punctate and opaque. Thorax and petiole coarsely, densely, rugosely punctate; parapsides finely, transversely aciculate; gaster smooth and shining. Scape brown at base, flagellum black, tips of femora, the tibiæ and tarsi ferruginous; rest of body metallic green. Wings slightly infuscated, veins and the distinct stigma brown.

Male: Similar to the female. The thorax is bronze in color, and the petiole proportionally thicker.

One male and two females, together with numerous pupæ were found at San Miguel in nests of *Pheidole vasleti* var. *acohlma*. The pupæ were lying among the brood of the ants, and were always quickly removed by the worker ants when the nest was uncovered.

This species is much larger than *O. occidentalis* Ashmead, from Southern California, but is otherwise very similar. *O. stramineipes* Cameron, from Panama differs in the form of the metanotum which has: "a central area bordered by keels which sharply converge at the top." This is entirely different to the structure of the metanotum in *tolteca*.

THE BACTERIAL DISEASES OF CATERPILLARS.[1]

By R. W. Glaser.

There seems to be a considerable amount of collateral evidence that caterpillars are subject to bacterial diseases, but I am not familiar with a single case where this has been conclusively proved. Such a state of affairs can be explained in part by the fact that much of the work on caterpillar diseases was done before the introduction of Koch's technical methods in 1880 or shortly after, before these methods had been fully perfected. Within compara-

[1] Contribution from the Bureau of Entomology in coöperation with the Bussey Institution of Harvard University. (Bussey Institution, No. 83.)

tively recent times diseases occurring in the same caterpillar, but totally different etiologically were confused with one another. The same name was often given to two distinct diseases and *vice versa*, the same disease was designated differently by different workers. Furthermore, the cultural and biological characters of the bacteria isolated were never thoroughly studied and hence no two investigators knew whether they were dealing with the same or different species. Many people untrained in bacteriology entered this field and helped to swell the enormous literature already accumulated with their inexact observations and careless experiments. Everyone familiar with the subject knows how difficult it is, how careful one has to be in drawing conclusions and how easily serious mistakes are made. From a consideration of some of the more important contributions to our knowledge of the bacterial diseases of caterpillars, the present condition of the subject will become apparent as well as the vast number of problems yet unsolved.

Flacherie and the Clinical Picture of an Infected Silkworm.

The diseases known as "flaccidezza," "lethargia," "negrons," "mortipans," "maladie de tripes," "maladie de morts-blancs," "maladie des morts-flats," "schlaff-sucht," "faulsucht," "flaccidity," "schizomycosis," and "caterpillar cholera" are synonymous with the one known as flacherie.

Flacherie appeared in the silk industry as an epidemic at the end of the sixteenth century. The larvæ usually contract the disease, which is characterized by its acuteness, after the fourth moult or at the time of spinning. Sick caterpillars show very few outer symptoms except loss of appetite and sluggishness. Sometimes their skin becomes black but in other cases they retain a healthy appearance till death. Soon after death the body becomes soft, flabby and dark colored in twenty-four to forty-eight hours and is filled with a brown-black liquid which is said to contain many bacteria.

The Etiological Factor of Flacherie in Silkworms and Other Caterpillars.

In 1870 Pasteur recognized flacherie in silkworms as a distinct disease capable of transmission to healthy larvæ by the infection of their food, either with the excrement of sick individuals or with

the dust of infected silkworm nurseries of the year before. Pasteur believed that a number of organisms, which multiplied in the intestine, were responsible for the disease. In 1873 Bolle found that bacteria were very plentiful in the bodies of silkworms affected with flacherie. In 1886, S. A. Forbes found that the alimentary canal of silkworms during the first stages of the disease was full of micrococci. He also obtained these micrococci from the blood in pure culture and believed them to be identical with *Steptococcus bombycis* described by Cohn. Forbes says that the disease can be transmitted by means of this bacterium and larvæ so infected die after twenty-four to forty-eight hours. He further states that the disease is not transmitted through the egg and that the bacteria retain their vitality for years.

In 1891 Macchiali found two organisms responsible for flacherie, namely, *Streptococcus bombycis* and a *Bacillus bombycis*.

In 1893 Wachtl and Kornauth expressed the belief that the bacteria found by Pasteur in 1870 are identical with *Microzyma bombycis* described by Béchamp in 1867 and identical with *Streptococcus bombycis* Cohn. At about the same time Cramer, Cuboni and Garbarini considered *Streptococcus bombycis* to be the causative agent of flacherie.

In general, *Streptococcus bombycis* seemed to be the form most frequently encountered and the controversy practically subsided with the acceptance of this bacterium as the etiological factor of flacherie in silkworms.

In 1903 Kelly made the remarkable statement that "flacherie is but another name for indigestion." Other theories as far-fetched as the above followed in rapid succession, the most extreme, perhaps, being the one advanced by Sawamura in 1906. He says: "The writer has inferred from his experiments that the flacherie of silkworms can be caused by various bacteria of general occurrence. During that disease no specific bacteria can be found which would be restricted to the occurrence in that epidemic. The following bacteria were found by the writer to produce flacherie by multiplying in the body of the silkworm:

1. *Bacillus coli.*
2. *Bacillus Ellenbachi.*
3. *Bacillus ferrugenus.*
4. *Bacillus fuchsinus.*

5. *Bacillus megaterium.*
6. *Bacillus megaterium bombycis.*
7. *Bacillus mycoides.*
8. *Bacillus pyocyaneus.*
9. *Bacillus rubefaciens.*
10. *Bacillus viridans.*
11. Various species of Proteus.
12. *Micrococcus (Staphylococcus) pyogenes aureus.*

Our knowledge of the etiology of flacherie in silkworms has not advanced in the least since Pasteur's time and the same thing can be said of other caterpillar diseases of a supposedly bacterial nature.

Forbes in 1886 and 1888 described flacherie-like diseases in the caterpillars of *Pieris (Pontia) rapæ*, *Datana ministra*, *Datana augusi*, *Mamestra picta*, *Pyrameis cardui*, and *Nephelodes violans*. In 1888 he said that "all the bacterial diseases of insects thus far carefully studied, take first and principal effect on the epithelial layer of the alimentary canal, no distinctively blood disease having yet been distinguished if we except a supposed flacherie of *Cleonus* larvæ reported by Metschnikoff in Russia, but not critically investigated."

The flacherie-like disease in caterpillars of the meal moth, described by Berliner in 1911, seems to begin with an acute intestinal disturbance which later affects the entire body, converting the interior into a brown liquid. In April, 1913, an article on Septicemia-like disease of caterpillars of *Arctia caja* L. appeared in the "Comptes Rendus des Séances de l'Académie des Sciences."

According to the authors Picard and Blanc, caterpillars dead from this disease become flaccid and give off a putrid odor. Their digestive tube is empty and contains a clear liquid often exempt from micro-organisms. The blood, however, contains a pure culture of what Picard and Blanc call a coccobacillus and with which they have artificially reproduced the disease. This coccobacillus for which they propose the name *Coccobacillus cajæ* measures about 1.5μ and is slightly oval. It is motile, and Gram negative but takes the anilin dyes readily. Cultures in bouillon grow in twelve hours at temperatures ranging from 15 degrees to 35 degrees, with an optimum growth at 25 degrees. The cultures have an odor resembling putrid eggs and in 24 hours assume a greenish fluorescent tint best obtained at the optimum growth temperature. The

cultures do not contain pyocyanin, however, as can be shown by extracting with chloroform. The coccobacillus grows rapidly on gelatine which it liquifies and on gélose (agar) the growth in two cases was slightly fluorescent. Streak cultures on gélose (agar) spread in a short time all over the surface. On potato the growth is feeble and begins to develop only after 48 hours without producing the greenish fluorescent pigment. Caterpillars of *Arctia caja* inoculated in the prolegs with a fine needle dipped in virulent blood or in a culture of bouillon die regularly in three days when kept at 15 degrees and present an intense multiplication of the bacillus in their blood. Inoculated caterpillars die in 12–24 hours when they are kept at a temperature of 25 degrees and the blood of such individuals appears more virulent than the blood of those which die at 15 degrees. If several drops of the culture are introduced into the pharynx by means of a pipette caterpillars die in 24 hours at 25 degrees and the coccobacilli invade the blood. This fact, that caterpillars can be infected by ingesting the etiological factor, leads the authors to hope for the employment of the disease practically.

Picard and Blanc found that brown-tail caterpillars are very susceptible to the coccobacillus. The authors inoculated several Coleoptera and Hemiptera, but found that the bacterium was non-pathogenic to these forms. White rats are also nonsusceptible to the intraperitoneal injection of a cubic centimeter of a virulent culture in bouillon, but the green frog (*Hyla arborea*) is susceptible and dies in 24–48 hours when inoculated in the lymphatic spaces. The blood from such a frog is again virulent for caterpillars.

The above results obtained by Picard and Blanc may have been correctly interpreted, but they can hardly expect bacteriologists to accept them for the following reasons: No account of their actual experiments is given; we know nothing about the number of caterpillars which were used, and no mention was made of controls. The absence of accurate controls alone places the article among worthless publications. Furthermore, the morphological description of their coccobacillus is very superficial and cultural features are almost entirely disregarded. They say nothing about colonies on nutrient gelatine or agar other than a growth was obtained on these media. Many other media absolutely essential

for a scientific treatment of the subject have been omitted. Apart from the pyocyanin test and the mention of temperatures all physical and biochemical characters have been ignored and the question which I would like to ask is: How do Picard and Blanc know that they were dealing with the same organism at all times?

Many of the authors reviewed seem to agree in one point, namely, that the flacherie-like diseases are primarily intestinal affections and that the bacteria concerned are found outside of the intestine, in the body cavity, only during the later stages when the alimentary canal ruptures.

Among certain human diseases somewhat analogous cases can be found. In typhoid fever, for instance, the main lesions of the disease occur in the intestine. Cholera is purely an intestinal affection characterized by diarrhœa in the form of the so-called rice water discharges. Among insects, European foul brood, a disease in bees caused by *Bacillus pluton*, is another example of such an intestinal malady.

While it therefore seems possible that some of the caterpillar diseases now grouped under the name of flacherie are intestinal disturbances caused by toxic products liberated within the alimentary tract by specific bacteria, it is not at all unlikely that other diseases affect other parts of the body such as the disease described by Picard and Blanc. The entire subject, however, is still one for controversy.

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PROTHETELY OR SEMI-PUPAL STAGE IN *LOPHEROS FRATERNUS* RAND.

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In the August number of Psyche (Vol. XXI, pp. 126–129) Williams mentions and illustrates an abnormal larva of *Photuris pennsylvanicus* that had developed the pupal wing pads, assigning Kolbe's term prothetely to the phenomenon, and citing the five previous records of this precocious development. Since photographic records of a parallel case in another genus of Malacoderm beetles are at hand they may be useful in close proximity to the above note to which an omitted case of similar nature may be added. Böving[1] 1906 speaks of an abnormal Donaciid larva:

"In a cocoon a larva with two large pupa wings on one side of the thorax, and a pupal abdomen was found. There was consequently no appendage, but the head and limbs were that of a larva. At the side of this monster, a cast off, entirely normal skin was lying, with the coverings of both cranium and limbs."

[1] Bidrag til kundskaben om Donaciin-larveneres naturhistorie, Copenhagen, p. 241. Translated into English 1910, Sonderabd. Int. Rev. Hydrobiol. Hydrograph. p. 101.